Causal Patterns in Ecosystems Rubrics: Understandings of Consequence Project

These rubrics are intended to help see whether students have achieved certain understandings and to diagnose the level of students' models and how they are structuring the causal concepts. The rubrics focus on causal understandings.

Scoring Advice:

- Decide on the answer or level of response that is closest to the student's and record it on the student's summary sheet.
- If a student gives two explanations where a lower level one is elaborated by a higher level one, score for the higher one. If a student gives two competing explanations, average the score of the two unless he or she clearly weights one much more than the other.
- Be sure to include information in any student diagrams when scoring his or her response.
- When scoring for causality, don't punish your less articulate students. Score for the level of causal model that they most likely understand even if they are not articulate about it. This helps you diagnose whether they understand the causal model even if they could have written a fuller explanation.
- Score with the same level of rigor on the pretest as on the post-test. Otherwise it will be difficult to see whether learning has taken place.
- Use each rubric to score only the dimension that it focuses on.
- Use the examples to offer an idea of what the level is asking for but don't let it limit your analysis. Use the description at that level instead.
- When a rubric says "OR" it means that an answer only has to satisfy one part of what it says in order to qualify at that level. If the student used two or more of the "OR" statements, it still gets scored at that level.

Question 1a: Sun, owls, insects, green plants, skunks, mice, toads, and earthworms are all found in an area near the school. Draw and explain the food web that they make up.

Assessment Aim: This question is scored twice: 1) to see if students focus on the patterns in the food web in terms of actions ("what eats what") or in terms of energy transfer—a more passive process; 2) to assess what students include in their food webs. Do they include only the more obvious actors—the primary and secondary consumers? Or do they also include the less obvious, yet critical, producers and decomposers? Do they include distant parts of the system—the sun?			
Content Understanding Goal: Energy Transfer			
Causal Understanding Goal: Passive Causality			
Level 1	Level 2	Level 3	Level 4
Focuses on active causality: Draws arrows from predator to prey and/or tells what eats what and/or what kills what. Examples: Skunks → Mice "Skunks eat the mice." Adds a human with gun or other animals such as a wolf and tells what each kills.	*Mixes active and passive causality*: Draws arrows from sun to green plants and/or green plants to consumers, but reverses arrows between predator and prey—showing what eats what. Examples: "The sun gives energy to the green plants. The rabbits eat the green plants."	*Shifts towards passive causality:* Draws arrows from prey to predator but doesn't talk about energy transfer or explains in terms of what eats what. Examples: Mice→skunks "Skunks eat mice" "Owls kill mice."	*Grasps energy transfer as a form of passive causality:* Draws arrows from prey to predator and describes energy transfer relationships. Examples: Mice→skunks "Mice provide energy for the skunks."
Content Understanding Goal: Role of Sun, Producers, Primary and Secondary Consumers, Decomposers			
Causal Understanding Goal: Obvious and Non-Obvious Causes			
Level 1	Level 2	Level 3	Level 4
Includes obvious components only: Includes primary and secondary consumers Examples: Includes skunks, mice, and toads	*Includes some obvious and some non-obvious components:* Includes producers and primary and secondary consumers OR Includes decomposers and primary and secondary consumers Examples: "green plants, skunks, mice, toads" or "skunks, mice, toads, and earthworms"	*Includes local obvious and non-obvious causes:* Includes producers, decomposers and primary and secondary consumers Examples: green plants, skunks, mice, toads, and earthworms"	*Includes obvious, non-obvious and non-local components:* Includes sun, producers and primary and secondary consumers and decomposers. Examples: "sun, green plants, skunks, mice, toads and earthworms"
**Unscoreable responses include: no response; "I don't know"; drawing pictures of different animals			

Question 1b: Are the green plants important to the other things? If so, circle the things below that green plants are important to: Owls; Mice; Insects; Earthworms; Skunks; Toads. Explain the reasons why the green plants are important to the things you circled.

Assessment Aim: This question assesses the connectedness that students see in the food web. It considers whether they detect the domino causality involved and if they see direct and indirect connections.			
Content Understanding Goal: Detecting Connectedness in Ecosystems			
Causal Understanding Goal: Domino Causality**,** Indirect Causality			
Level 1	Level 2	Level 3	Level 4
No connections given: Says that the green plants are important but does not elaborate on the principles behind the statement. Examples: "The green plants are important."	*Describes a one-step linear or branching, one-way connection:* Producers are important only to primary consumers or sees the importance to secondary consumers as having to do with contributions other than energy transfer. Examples: "The green plants are important to the insects because they give the insects energy." "The green plants matter only to the things that eat them, like the insects and the mice." "The green plants only matter to insects for getting food but they help the rest of the things to breathe."	*Describes two-step, linear connections with indirect components:* Producers are important to the primary consumers because they eat them and to the secondary consumers because they eat the primary consumers. Examples: "The insects eat the green plants and the toads eat the insects."	*Describes multi-step linear connections of three or more steps with indirect components:* Examples: "The insects eat the green plants and the toads eat the insects and the skunks eat the toads." "The green plants are important to everything because they make the energy from the sun into food and everything else uses that energy."
**Unscoreable responses include: no response; "I don't know"; drawing pictures of different animals; not a food chain or food web			

Question 1c: Are owls important to mice? Yes or no? Why or why not? Are mice important to owls? Yes or no? Why or why not?

Assessment Aim: This question considers whether students detect the mutual aspects of feeding relationships in the food web. Individual organisms benefit in terms of gaining energy and populations of animals are kept in balance by the activities of the predators. Because these benefits construe to the population rather than the individual, many students have difficulty recognizing them.			
Content Understanding Goal: Detecting Connectedness and Balance in Ecosystems			
Causal Understanding Goal: Mutual Causality**,** Population Reasoning			
Level 1	Level 2	Level 3	Level 4
Makes a one-way connection: Gives a predator-prey relationship that is described only from the perspective of the predator. Examples: "The mice are important to the owls because they are food for them. Owls aren't important to mice."	*Makes a two way connection but at the level of individuals:* Both owls and mice are impacted but not at the level of population effects. Examples: "The owl gets food but the mouse dies." "Mice help owls but owls kill mice."	*Makes a two way connection focused on the individual benefits to predators and population effects to prey OR a one way connection focused only on the population effect to the prey:* Mice are impacted at the population level and owls gain energy. Example: "If there are too many mice, there won't be enough food for them, so the owls keep the numbers of mice to a good size."	*Makes a two way connection where predator and prey are impacted at the level of population effects:* Mice and owls are both impacted at the population level. Example: "The owls get food (or energy from the mice) and the mouse population stays a good size (or in balance)."
**Unscoreable responses include: no response; "I don't know"; drawing pictures of different animals; not a food chain or food web			

Question 2: What happens to a tree in the forest when it dies? What would happen to the tree after a few years?

Assessment Aim: This question has multiple parts. It considers whether students understand that organisms decompose and are broken down into reusable matter as part of the matter cycle.			
Content Understanding Goal: Change Over Time and Matter Recycling			
Causal Understanding Goal: Predicted Change			
Level 1	Level 2	Level 3	Level 4
Does not expect a change: Nothing would happen to the tree. Example: "The tree is dead."	*Expects changes **not** related to the decomposition of the dead tree or focuses on near term changes:* Focuses on the tree as a habitat, that it would no longer have leaves, gets knocked over. Example: "Animals live in the dead tree."	*Expects changes over time that relate to the tree breaking down or falling apart.* Focuses on it breaking up. Examples: "After a while, it would fall apart." "Bugs would live in the tree and the tree gets broken down."	*Expects changes over time and focuses on longer term changes that relate to the tree becoming part of the soil.* Focuses on it becoming soil. Example: "After a while, the actual tree goes away--it becomes a part of the soil."
Content Understanding Goal: Matter Recycling			
Causal Understanding Goal: Cyclic Causality			
Level 1	Level 2	Level 3	Level 4
Focuses on location of the tree or ability to find the tree after a few years: Describes how its location might change because it had been moved by water, wind, animal, etc. Examples: "An animal might move it." "It would be gone; maybe water took it away." "It would blow away."	*Focuses on appearance of the tree after a few years: D*escribes how the tree would appear on a superficial level. . Examples: "It turns brown." "It looks bad." "It wouldn't have lots of branches."	*Focuses on a weakening of tree's structure in some way that distinguishes from simple change in appearance:* Explains how the tree can no longer be recognized as it once was, but does not talk about recycling of matter. Examples: "It is falling apart." "It disappears." "It gets eaten by bugs." "It shrinks until you can't see it." "It disintegrates."	*Focuses on structural change at the micro-level:* Explicitly recognizes the recycling of matter. Examples: "It turns into rich soil." "It gets broken down into soil"
**Unscoreable responses include: no response; "I don't know"			

Question 3: What causes this to happen?

Assessment Aim: This question has multiple parts. It considers whether students understand that organisms decompose, that there are obvious and non-obvious causes for decomposition, and that decomposition depends upon reliable, on-going causes.			
Content Understanding Goal: Role of Decomposers			
Causal Understanding Goal: Existence of Causal Mechanism			
Level 1	Level 2	Level 3	Level 4
Does not expect a change: Nothing would happen to the tree. Example: "The tree is dead."	*Acknowledges that change happens, but does not attribute the changes to a causal mechanism:* Says that it just happens but doesn't give a cause. Example: "It just breaks down."	*Attributes the changes to the lack of a cause actively keeping it together:* Says that things just get old and fall apart after a while. Example: "Once the tree dies, it loses its strength and eventually, it just falls apart."	*Attributes the changes to a causal mechanism:* Something makes the changes happen. Example: "It breaks down because bugs are eating it."
Content Understanding Goal: Role of Decomposers and Matter Recycling			
Causal Understanding Goal: Obvious and Non-Obvious Causes			
Level 1	Level 2	Level 3	Level 4
Does not describe any causes: Does not mention decomposers, thinks nothing will happen or does not account for changes. Example: "It gets brown and mushy." "Nothing happens."	*Describes only obvious causes of decomposition:* Attributes changes to causes that one can see such as earthworms and sow bugs. Examples: "Earthworms break down the dead matter." "Bugs eating garbage and dead leaves."	*Describes only non-obvious causes of decomposition:* Attributes changes to microbes as the primary decomposers. Example: "Bacteria breaks down dead matter by digesting it."	*Describes obvious and non-obvious causes of decomposition.* Attributes changes to observable (such as earthworms) and non-observable causes (such as microbes.) Example: "Decomposers like earthworms and microbes break down dead matter by digesting it."
Content Understanding Goal: The Nature of Decomposers			
Causal Understanding Goal: Characterization of the Causal Mechanism			
Level 1	Level 2	Level 3	Level 4
Does not describe any causes: Does not mention decomposers, thinks nothing will happen, or does not account for changes. Examples: "It turns brown." "Nothing happens."	*Describes unreliable causes*: Attributes changes to things that may or may not happen. Examples: "Animals happen to sit on it." "A thunderstorm could do it."	*Describes processes or conditions as the cause:* Attributes changes to background conditions (heat, wetness, aging, rain) that may or may not affect rate of decay. Example: "The sun or wind dries it out."	Describes on-going, reliable micro causes: Talks about the role of micro- (molds, bacteria) or macro- (worms, sow bugs) decomposers Example: "Bacteria feed on and break down dead matter." "Worms digest it and it is broken up into the soil."
**Unscoreable responses include: no response; "I don't know"			

Question 4: Is what happens to the tree important to the plants in the forest? If so, how? If not, why not? Is what happens to the tree important to the animals in the forest? If so, how? If not, why not?

Assessment Aim: This question is scored twice. It considers whether students see decomposition as part of the larger phenomenon of matter recycling. It also assesses whether students grasp the cyclic nature of the process and the conservation of matter that it entails.			
Content Understanding Goal: Matter Recycling			
Causal Understanding Goal: Cyclic Causality			
Level 1	Level 2	Level 3	Level 4
Does not mention a cycle: Gives responses that do not recognize the cyclic pattern. Examples: "It's important because it is part of life." "It's what happens next after the tree dies."	*Mentions cycles or circles without explanation:* Says it's like a cycle but doesn't connect it to matter recycling. Examples: "It's like a cycle." "It's like the circle of life."	*Mentions decay as part of recycling:* Says that decay turns dead matter back into soil or stuff in the soil. Examples: "It turns back into dirt." "The tree grows using the soil and then becomes soil again."	*Mentions decay as part of recycling AND discusses it as a circle or recycling:* Says that dead matter turns back into soil and this is like a circle or recycling. Example: "It turns back into soil. This is part of a big cycle that creates rich soil which helps the plants to grow and then they die and create more soil."
Content Understanding Goal: Matter Recycling			
Causal Understanding Goal: Conservation of Matter, Cyclic Causality			
Level 1	Level 2	Level 3	Level 4
Does not view decay as important: Examples: "It's what happens, but if it didn't, it wouldn't be such a big deal." "Dead things might smell, but that's all."	*Does not recognize the finite nature of matter, but considers decay essential, otherwise dead matter would accumulate..* Examples: "If nothing decayed, there'd be tons of dead matter everywhere until there would be no room for anything else." "It's like the circle of life."	*Does not mention the finite nature of matter, but believes that decay is essential for having good soil.* Example: "If nothing decayed, there wouldn't be good rich dirt to grow plants in."	*Recognizes that matter is finite and is recycled:* Recognizes that if dead matter was not recycled, that the building blocks for new life would not exist. Examples: "The particles go back into the soil to become a part of new things." "The matter in the tree will become the matter in something else someday."
**Unscoreable responses include: no response; "I don't know"			

Question 5a: What is balance in an ecosystem and what makes it happen?

Assessment Aim: This question considers whether students have a concept of balance at the population level, whether they view balance as playing a role in ecosystem stability, and if they have a sense of factors that lead to balance.			
Content Understanding Goal: Understanding Balance in Ecosystems			
Causal Understanding Goal: Mutual Causality**,** Population Reasoning, Cyclic Causality			
Level 1	Level 2	Level 3	Level 4
Has a concept of balance, but not as it pertains to the abstract concepts in an ecosystem: Describes balance in terms of a seesaw, a balance scale, not tipping over, etc. Example: "If something is in balance, like a seesaw, then the two sides even out."	*Views balance in terms of individual organisms and mutual causality:* Animals have to eat certain amounts or they will deplete their diet sources. Example: "If a snake eats too many mice, then it will run out of mice to eat."	*Views balance as a population effect:* In order for an ecosystem to be in balance, the sizes of the populations of organisms has to be just right for the populations of the things that they need to eat. Example: "The numbers of each animal has to be in the right balance with the numbers of the animals that it feeds upon for there to be balance."	*Views balance as what creates stability at the level of populations, Might understand factors that give rise to it:* When things are in balance, organisms have what they need to survive. Might describe measures of redundancy (multiple acceptable food sources or habitats) and adaptability (switch food sources or habitats) that provide balance. Example: "Balance means that all the animals have what they need and the ecosystem stays pretty much the same. If it is out of balance, things will die out and things can crash quickly."
**Unscoreable responses include: no response; "I don't know"			

Question 5b: A student said, "It is good for ecosystems to always be in balance." Do you agree or disagree? Why or why not?"

Assessment Aim: This question considers whether students understand that both balance and flux play important roles in ecosystems. Often students believe that only balance is good and all flux is bad.			
Content Understanding Goal: Balance and Flux in Ecosystems			
Causal Understanding Goal: Mutual Causality**,** Population Reasoning, Cyclic Causality			
Level 1	Level 2	Level 3	Level 4
Views only the negative aspects of flux: States that it is bad for an ecosystem to be in flux because it is unstable. Example: "If ecosystems are in flux, species can die out."	*Views balance as essential:* Stresses that ecosystems should always be in balance or that balance is the best or "natural" state. Example: "It is important for ecosystems to remain in balance. For example if skunks can't find mice to eat they can eat snakes or green plants."	*Suggests that constant balance might be limiting:* States that it is bad for ecosystems to always be in balance because it limits changes and that may be unhealthy in the long term. Example: "If ecosystems are always in balance, how would new species become established?"	*Sees the value of balance and flux:* Considers balance and flux to play important role in ecosystems. Example: "Balance and flux both have roles in ecosystems. More mice than predators can keep in check might result in an unbalanced population until an event like a dry spell causes large numbers of mice to die off."
**Unscoreable responses include: no response; "I don't know"			